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Dual Economy Models : A Primer for Growth Economists

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DUAL ECONOMY MODELS: A PRIMER FOR GROWTH ECONOMISTS

by
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This paper argues that dual economy models deserve a central place in the analysis of growth in developing countries. The paper shows how these models can be used to analyse the output losses associated with factor misallocation, aggregate growth in the presence of factor market distortions, international differences in sectoral productivity and the potential role of increasing returns to scale. Above all, small-scale general equilibrium models can be used to investigate the interactions between growth and labour markets, to shed new light on the origins of pro-poor and labour-intensive growth, and to explore the role of the informal sector.

1 Introduction

Although not quite a truth universally acknowledged, growth economics is beginning to acquire a distinct identity, with many researchers regarded primarily as ‘growth economists’, the emergence of a new field journal (the *Journal of Economic Growth*), and an increasing number of textbooks devoted to the field. Compared with the previous surge in growth research, that of the 1960s, an important strength of recent work is the interaction of theory and evidence. The development of the Penn World Table and the availability of longer spans of data have both been important: there is renewed scope for investigating why income levels and growth rates differ so widely across countries. Even for those instinctively suspicious of cross-country growth regressions, it would be hard to claim that nothing has been learnt from recent studies in the development accounting literature, or from the quantitative investigations, based on the predictions of calibrated structural models, that are beginning to accompany it.

Historically, the organizing framework for most empirical growth research has been the one-sector neoclassical growth model. As originally formulated by Solow (1956) and Swan (1956), this model revealed the possibility of a balanced growth path with a constant real interest rate.

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Although the steady-state result continues to dominate the way many growth economists think and write about their field, this dominance might strike outside observers as surprising. After all, many growth economists are chiefly interested in the growth of developing countries. It is not obvious, at first sight, that a model with a long-run steady state is necessarily the best way to think about economic development. This process could be seen as inherently a transition, from one form of economy to something very different. The stylized apparatus of balanced growth paths might have little to say about many events that are central to this transition.[1]

For well over a decade, the paper that best answers this criticism has been Mankiw *et al.* (1992). They showed how the Solow model, when applied to a cross-section of countries, can be used to generate sharp predictions about differences in income levels and in growth rates. Their addition of human capital to the Solow model leads to quantitative predictions that look consistent with the data. The influence of these ideas can then be traced through subsequent research, notably Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997), that has also deepened our understanding of productivity at the aggregate level.

In some crucial respects, however, the empirical success of the neoclassical model may have been damaging. This paper emphasizes a line of research that predates the Solow model, continues to be developed in parallel to it and may have a great deal to say about crucial issues—yet is largely absent from textbooks on economic growth, and rarely informs empirical research. This is the tradition of dual economy models, or small-scale general equilibrium models with a sizeable agricultural sector. Although much studied by development economists and trade theorists, these models have recently fallen into neglect.

To see why models of dual economies might have interesting, even urgent, things to say, it helps to step back and ask: what are the crucial unresolved issues in growth economics? One of the most intensively studied areas, the econometric study of convergence, has found increasingly sophisticated ways to describe the evolution of the world income distribution, but has not generated much of direct use to policymakers. From the perspective of a government in a low-income country, the questions of interest surely look very different.

Above all, one might be interested in policies that simultaneously achieve two aims—raising productivity and lifting as many people as possible out of poverty. When the President of South Africa, Thabo Mbeki, talks about 'the second economy' of his country, he is referring to the marginalized poor, and the possibility they will not benefit from economic growth, however rapid.

[1]See Lucas (2002) for several contributions that emphasize the transitional aspects of development. The integration of development transitions with conventional long-run outcomes, such as balanced growth paths, will be discussed later in the paper.

The same issues arise for the giants India and China, as these nascent superpowers continue their rapid growth. In each case, there is much discussion, even anxiety, over whether particular sectors or regions will be left behind. Looking further afield, a central question for many developing countries is whether economic growth can help to reduce urban underemployment. Which policies will promote 'labour-intensive' growth, and raise the incomes of the poorest individuals?

These questions are hard to think about. They require a general equilibrium approach, one that acknowledges the interdependence of different sectors, and that explicitly allows the possibility of different types of growth. There is a long tradition of thinking about these issues in development economics, leading to a vast literature on dual economies. However, work by growth economists, whether at the research frontier or in writing textbooks, has only rarely acknowledged this tradition. Instead, the dominant focus on a one-sector model, and on steady states, has precluded some of the most interesting questions from even being asked.

This paper will seek to lower the entry barriers to the literature on dualism, with an emphasis on the results and properties of dual economy models that seem most relevant to growth economics. The paper is designed to complement the book-length, illuminating treatments of Mundlak (2000) and Ros (2000), with a greater emphasis here on implications for cross-country data and on factor market distortions. In what follows, I will describe how dual economy models can be used to analyse factor misallocation, urban unemployment, multiple equilibria, international productivity differences and growth in the presence of structural change. An advantage of integrating these questions in a single paper is that one can point to a common underlying structure, in which different models can be seen as specific departures from the standard 2×2 model of trade theory.

I will adopt an unconventionally broad definition of dualism, namely that a non-agricultural sector (industry and services) coexists with a sizeable agricultural sector. For the most part, I will concentrate on models where the agricultural sector is perfectly competitive and characterized by a market-clearing wage; this decision arises for reasons of lack of both space and expertise, rather than realism.[2]

In contrast, the paper will have more to say about the nature of the urban labour market, given that substantial urban underemployment is a well-known feature of many developing countries. Using a classification of dual economy models due to Bertrand and Squire (1980), the analysis in the paper is closer to models of 'modern sector dualism' (or an imperfect labour market) rather than 'traditional sector dualism' (where the wage exceeds the marginal product in agriculture, or the agricultural wage is independent

[2]The nature of agricultural labour markets is discussed in more detail by Rosenzweig (1988) and in textbooks on development economics such as Ray (1998) and Bardhan and Udry (1999).

of labour demand in the modern sector). There are many issues that have historically been central to the literature on dual economies—such as the generation of an agricultural surplus, or the establishment of development 'turning points'—that I will sidestep. For a more detailed treatment of these issues, see Kanbur and McIntosh (1988), Ranis (1988) and Fei and Ranis (1997).

The uses of dual economy models are not confined to modern-day developing countries. Many of the ideas discussed in this paper can be applied to the post-war 'Golden Age' of rapid growth in Europe (as in Cornwall, 1977; Temple, 2001); the convergence of different regions within the USA, studied by Caselli and Coleman (2001) and Dennis and Işçan (2004); and in consideration of Japan's economic history, as in Jorgenson (1966).

However, it remains easy to question the importance of dualism for understanding growth. What should an enthusiast for dual economy ideas say to readers of Mankiw, Romer and Weil (1992) or to anyone with a natural preference for the simplicity of a one-sector model? First of all, recall that the Mankiw, Romer and Well approach is based on an aggregate production function. But this appears a somewhat artificial construction, if the economies under study are very different in sectoral structure. For example, it is easy to show that if two sectors each have Cobb–Douglas production technologies, and if the exponents on inputs differ across sectors, the aggregate production function cannot be Cobb–Douglas.[3]

This is not the only assumption in the growth regression literature to be on shaky ground. An especially ingenious contribution of Mankiw, Romer and Weil was to find a way to estimate technology parameters even when reliable capital stock data are absent. As is well known, their version of the Solow model assumes that the growth rate of efficiency is the same for all countries in a given sample. When the sample at hand combines predominantly agricultural economies with the very different member countries of the Organization for Economic Cooperation and Development (OECD), this assumption of common technical progress looks tenuous at best. As will be discussed later, two-sector models lead to an alternative and potentially more informative treatment of efficiency differences, whether in levels or growth rates.

A final criticism of the one-sector approach is that it has little to say about economies that are at least partly agricultural. Above all, one-sector models cannot address the changes in employment structure, away from agriculture and towards manufacturing and services, that are currently under way on a vast scale in parts of the developing world, including China. Even if we confine attention to static comparisons of productivity levels, agriculture deserves attention. Note that aggregate output per worker can be written as a weighted average of labour productivity in agriculture and non-agriculture,

[3]See Temple and Woessmann (2004) for more discussion of aggregation in two-sector models.

where the weights are the shares of each sector in total employment. Since historically the agricultural sector has often accounted for the largest share of employment, it becomes important to think about this sector's contribution to aggregate growth.[4]

Given the potential usefulness of dual economy models, it is interesting to ask why dualism is not more central to the recent growth literature. Three reasons stand out. The first is that the study of dual economies demands an eclectic approach, combining ideas from agricultural and development economics, trade theory and labour economics. Second, there is often a perception that two-sector models lead to technical problems that are difficult to resolve, and require special assumptions that preclude useful or portable results. This paper will aim to show this claim is mistaken: stripped to their essentials, two-sector models have implications for aggregate outcomes that are often straightforward.

These two reasons are related to a third, namely that some growth economists seem reluctant to forsake their graduate school training in balanced growth paths and steady states. There is much to be learnt about growth for which the concept of a balanced growth path is largely irrelevant. For example, it is increasingly well known that the conditions for the existence of a balanced growth path, in the presence of multiple sectors, are rather strict. Kongsamut *et al.* (2001) and Ngai and Pissarides (2004) provide recent treatments. One response is that we need an alternative model, but an equally valid response is to ask: if we are thinking primarily about growth in developing countries, why are we looking for balanced growth paths in the first place?

This point is discussed in Temple (2003a), but a more succint argument can be found in Solow (2000, p. 100). There, Solow argues that we should use the term 'growth' to think about anything that changes the level of the growth path, rather than focusing exclusively on the properties of the growth rate in a long-run steady state. This may seem too obvious to need saying, but otherwise a sign marked 'steady state required' can too easily close off a productive line of enquiry. For example, using a two-sector model to think about the effects of a step change in productivity, such as the Green Revolution in agricultural technologies, could be highly informative about a particular growth episode. It is a mistake to think that an understanding of economic development can only ever be gained by analysing dynamic models, and an even worse mistake to assume that steady-state growth paths are an essential requirement of a rigorous analysis.[5]

[4]Temple (2003b) uses some simple calculations, based on a two-sector model, to illustrate the potential contribution of agricultural total factor productivity (TFP) growth to growth in aggregate output.

[5]Kanbur and McIntosh (1988) also emphasize this point in relation to dual economy models. As will be discussed later, they argue that a genuinely long-run analysis of a dual economy would need to treat the extent of dualism (defined as factor market distortions, say) as endogenous.

The criticism that too much growth research ignores dualism and structural change is not new to this paper. The same point can be found in Stern (1991), Pack (1992), Naqvi (1996) and Ruttan (1998) among others. Much earlier, Kelley *et al*. (1972) and Kelley and Williamson (1973) had already pointed out that conventional approaches can yield misleading findings when applied to dual economies. What is different now is that a number of growth economists and macroeconomists are beginning to examine again the empirical implications of dual economy models.[6] In a sense, this paper can be seen as sketching in some of the background to this recent work, and complements the longer and deeper treatments in Mundlak (2000) and Ros (2000). The textbooks by Basu (1997), Ray (1998) and Bardhan and Udry (1999) also include useful discussions of dualism.

The remainder of the paper has the following structure. Section 2 briefly describes some stylized facts on the employment and output structures of modern-day developing countries. Section 3 sets out the benchmark 2×2 model of trade theory, which forms the implicit or explicit background for many more sophisticated analyses. Section 4 introduces labour market distortions. Section 5 briefly considers two-sector models with increasing returns. The implications of these various models for levels accounting decompositions are reviewed in Section 6. Then, Sections 7 and 8 sketch the implications of two-sector models for the study of structural change and aggregate growth. Section 9 reviews some variants on the small open economy model, while Section 10 argues that one especially important research agenda is the interaction of growth and labour markets. Finally, Section 11 concludes.

2 Some Stylized Facts

This section describes the patterns of structural change observed in five groups of countries since 1960, drawing heavily on Temple and Woessmann (2004). A straightforward (and probably obvious) point is that structural change has been substantial over the time period usually addressed by growth regressions. Less obviously, the data are potentially consistent with significant wage differentials across sectors, but not consistent with Cobb–Douglas production functions and a fixed wage differential.

First, define Y_a and Y_m as real outputs in agriculture and non-agriculture respectively. L_a and L_m are the respective labour forces. The price of the agricultural good will be normalized to one, and p is the relative price of the non-agricultural good. In what follows, the two variables s and a will

[6]These contributions include Paci and Pigliaru (1999), Robertson (1999), Parente and Prescott (2000, 2004), Parente *et al*. (2000), Graham and Temple (2001), Temple (2001, 2004), Gollin *et al*. (2002a, 2002b, 2004), Hansen and Prescott (2002), Chanda and Dalgaard (2003), Landon-Lane and Robertson (2003), Restuccia *et al*. (2003), Caselli (2004), Temple and Woessmann (2004) and Vollrath (2004).

often be important: these are the output and employment shares of agriculture, namely

$$s = \frac{Y_{\mathrm{a}}}{Y_{\mathrm{a}} + pY_{\mathrm{m}}}$$

$$a = \frac{L_{\mathrm{a}}}{L}$$

where L is the total labour force. Note that the output share is evaluated at the domestic relative price, rather than at a common set of international prices. For many purposes this nominal output share is the appropriate choice, since it is the domestic relative price that will determine intersectoral allocations of capital, labour and other inputs. The use of purchasing power parity adjusted output shares will be discussed later in the paper.

Table 1, from Temple and Woessmann (2004), shows figures for agriculture's share of employment (a) and share of nominal value added (s) for five country groupings, in 1960, 1980 and 1996. The figures are medians for each region.[7] Looking at Table 1, an immediate observation is that many developing economies have large agricultural sectors, and that agriculture is often the main source of employment. This is clearly the case for sub-Saharan Africa and south Asia, even in 1996. Although most empirical growth research is based on data for two or three decades since 1960, the word 'agriculture' is rarely found in the text of these papers, let alone the abstract. Moreover, these papers only rarely acknowledge structural change. However, most regions of the developing world have seen a transformation in the structure of output and employment between 1960 and 1996.

Table 1 also reports a median figure for a measure of relative labour productivity in the two sectors, RLP. This is the ratio of the average product of labour in the two sectors:

$$\mathrm{RLP} = \frac{pY_{\mathrm{m}}/L_{\mathrm{m}}}{Y_{\mathrm{a}}/L_{\mathrm{a}}} = \frac{1-s}{s}\frac{a}{1-a}$$

Based directly on the output and employment shares, Table 1 shows that average labour productivity is substantially higher outside agriculture, a well-known finding that is discussed in Kuznets (1971), Chenery and Syrquin (1975), Mundlak (2000) and Gollin *et al.* (2004), among many others. The differences in average productivity should not be used to conclude that agriculture, or the allocation of factors across sectors, is somehow inefficient,

[7]The data on employment shares are from the Statistical Database of the Food and Agricultural Organization of the United Nations (FAO) (2003). The data on value added shares are from the World Bank's (2002) World Development Indicators (WDI). Where necessary, the WDI data have been supplemented with figures for 1960 taken from the 1990 Production Yearbook of the FAO and the 1987 World Development Report of the World Bank.

Table 1
Employment and Output Shares of Agriculture in 1960, 1980 and 1996

	Employment share (a)			*Output share (s)*			*Relative productivity*			*Sample sizes*		
	1960	*1980*	*1996*	*1960*	*1980*	*1996*	*1960*	*1980*	*1996*	*a*	*s*	*RLP*
Sub-Saharan Africa	0.88	0.76	0.71	0.39	0.30	0.37	11.8	8.7	6.1	19	16	16
East Asia and Pacific	0.62	0.39	0.17	0.29	0.19	0.08	3.4	3.3	2.8	10	8	7
South Asia	0.75	0.70	0.60	0.46	0.34	0.25	3.2	3.2	3.4	5	4	4
Latin America/Caribbean	0.53	0.36	0.23	0.23	0.12	0.09	3.8	3.4	2.2	20	18	18
High-income OECD	0.19	0.08	0.05	0.11	0.05	0.03	2.4	1.8	1.7	20	16	16

Notes: Medians within each country grouping. Own calculations based on World Bank (2002) and the Food and Agricultural Organization of the United Nations (2003); see text for details.
a, share of agricultural employment in total employment; *s*, share of agricultural value added in total value added. 'Relative productivity' is the ratio of average labour productivity in non-agriculture to that in agriculture (see text). 'Sample sizes' is the number of countries in each regional sample.

although this is a surprisingly common misinterpretation. Differences in average products will usually be a feature of an efficient allocation, since output is maximized by equating marginal products, not average products.

A simple way to relate marginal and average products is to assume that technologies in the two sectors are both constant-returns Cobb–Douglas, but with different exponents on capital and labour:

$$\begin{aligned} Y_{\mathrm{a}} &= A_{\mathrm{a}} K_{\mathrm{a}}^{\alpha} L_{\mathrm{a}}^{1-\alpha} \\ Y_{\mathrm{m}} &= A_{\mathrm{m}} K_{\mathrm{m}}^{\theta} L_{\mathrm{m}}^{1-\theta} \end{aligned} \tag{1}$$

Then the ratio of marginal value products is given by

$$\frac{w_{\mathrm{m}}}{w_{\mathrm{a}}} = \frac{1-\theta}{1-\alpha} \frac{pY_{\mathrm{m}}/L_{\mathrm{m}}}{Y_{\mathrm{a}}/L_{\mathrm{a}}} = \frac{1-\theta}{1-\alpha} \mathrm{RLP} \tag{2}$$

This expression for the wage differential is just a version of the well-known property of Cobb–Douglas technologies, that marginal products are proportional to average products. If we make the usual (sometimes incorrect) assumption that the non-agricultural sector is more capital intensive ($\theta > \alpha$) then it is possible that the marginal products in the two sectors are equal even when, as in Table 1, RLP is greater than one.

There are good reasons to be suspicious of the figures on relative productivity. It is likely that urban labour is more skilled on average, an issue that will be discussed later in the paper. In poorer countries a substantial fraction of agricultural output may be unmeasured in the national accounts, as discussed in Parente *et al.* (2000). Schmitt (1989) points out various dangers of interpreting measures like RLP too literally, especially given that some agricultural labour is allocated to non-farm activities. For all these reasons, it seems likely that RLP overstates the relative productivity of workers in non-agriculture.

Another interesting aspect of Table 1 is that, for most regions, the relative productivity of non-agriculture declines between 1960 and 1996. This pattern is not universal, but Mundlak (2000, p. 11) finds that productivity in non-agriculture has fallen relative to that in agriculture for about four-fifths of the 87 countries he considers, between 1960 and 1992. Based on earlier patterns, Chenery and Syrquin (1975, p. 53) had argued that relative productivity in industry and services may increase in the early stages of development, before ultimately declining. In contrast, the Table 1 figures, and those reported in Mundlak (2000), suggest that the relative productivity of agriculture improves even at low levels of development.

From equation (2), the declines in relative productivity contradict a simple model with Cobb–Douglas technologies in each sector and a fixed wage differential. The declines are consistent with a marginal product differential across sectors that is gradually being eliminated over time, but other explanations are possible. These include measurement issues and departures

from the Cobb–Douglas assumption (see Gollin *et al.* (2004) for more discussion).

3 Modelling a Small Open Economy

As an organizing framework for much of the paper, I start from what may be the simplest useful model. Consider a small open economy in which there are two sectors, producing distinct goods. In most of what follows, it will be useful to think of these two sectors as rural agriculture and urban non-agriculture (industry and services). Both sectors are assumed to be perfectly competitive, and all agents are price takers.

The economy is closed to international movements of capital and labour, but the output of both sectors can be traded on world markets. For simplicity, assume there are no taxes or subsidies for domestic producers, nor are there tariffs or export subsidies. In this case, the prices received by domestic producers are equal to the prices of the goods on world markets. Furthermore, assume that domestic output of each good is a sufficiently small fraction of world production that the world prices can be taken as determined independently of domestic output. This is the 'small' aspect of the small open economy assumption.

These assumptions are strong, but also help to simplify the analysis a great deal. Under these assumptions, world prices tie down the prices of the two goods. The agricultural good is treated as the numéraire, with a price of unity. The exogenous relative price of the non-agricultural good is denoted p. In principle, we could choose units for this good so that its price could also be normalized to one, but I retain an explicit role for the relative price to allow simpler consideration of cases where relative prices vary over time or space.

Total output is given by

$$Y = Y_{\mathrm{a}} + pY_{\mathrm{m}}$$

where, as before, Y_{a} and Y_{m} are outputs in agriculture and non-agriculture respectively. This is a measure of output in terms of agricultural goods but, if the relative price is constant, it can also be taken as a measure of real output. If the relative price varies over time or space, we need to compute a quantity index for real output, e.g. by deflating nominal output by an appropriate price index.[8]

The key advantage of the small open economy assumptions is that, given exogenous prices, we can study equilibrium in this economy without having to think about the nature of preferences and demand. To put this differently,

[8]Given the open economy setting, there is an important distinction between a GDP price index and a cost-of-living index. The distinction arises because the structure of consumption differs from that of production. See Feenstra (2004, Appendix A) for discussion.

the remainder of the analysis will be valid for many possible sets of preferences. If we specified a particular utility function for a representative consumer, we would know more about consumption of each good relative to domestic production, and hence the quantities that are imported or exported. But if we are mainly interested in the study of sectoral allocations and aggregate outcomes, we can proceed without specifying preferences. In terms of trade theory, we are studying a simple general equilibrium model of production.

For a growth economist, potentially interesting issues include the allocations of factors between sectors, the determination of aggregate output and changes in these outcomes over time. A useful benchmark is the standard trade theory model with two sectors and two factors (the 2×2 model). I now briefly sketch this model, assuming that technologies, endowments and parameters are such that the economy is incompletely specialized—in other words, output is strictly positive in both sectors. Although the model is very simple, it is a great help in understanding the structure of related but more complex models.

We will call the two factors capital and labour. Assume that the production functions in the two sectors have constant returns to scale and diminishing returns to each input, and are given by

$$\begin{aligned} Y_{\mathrm{a}} &= A_{\mathrm{a}} F(K_{\mathrm{a}}, L_{\mathrm{a}}) \\ Y_{\mathrm{m}} &= A_{\mathrm{m}} G(K_{\mathrm{m}}, L_{\mathrm{m}}) \end{aligned} \tag{3}$$

where A_{a} and A_{m} are total factor productivity levels in agriculture and non-agriculture, respectively, and remaining notation is standard.

Assume that the total quantities of capital and labour are fixed. For now, we assume both factors are fully employed, so that we have

$$L_{\mathrm{a}} + L_{\mathrm{m}} = L \tag{4}$$

$$K_{\mathrm{a}} + K_{\mathrm{m}} = K \tag{5}$$

where L and K are aggregate employment and capital respectively. One might wonder where the capital comes from, but the assumptions about trade mean that distinctions between consumption goods and capital goods can be disregarded for now. For example, capital goods can be imported as required.

We assume that workers are paid the values of their marginal products, so we have

$$\begin{aligned} w_{\mathrm{a}} &= A_{\mathrm{a}} F_L \\ w_{\mathrm{m}} &= p A_{\mathrm{m}} G_L \end{aligned} \tag{6}$$

where the L subscript denotes the partial derivative with respect to labour. For now, assume that workers will migrate between sectors unless wages are equalized. In equilibrium we then have

$$w_m = w_a \tag{7}$$

Capital also receives its marginal product in both sectors. If we assume that capital is perfectly mobile between sectors, any difference in rental rates is immediately eliminated, and so using the same notation we have

$$pA_m G_K = A_a F_K = r \tag{8}$$

where r is the rental rate on capital (which may differ from the real interest rate, for the usual reasons).

This simple structure provides 10 equations in 10 unknowns. Under appropriate conditions these can be solved for the intersectoral factor allocations, factor prices and sectoral outputs. A much deeper treatment can be found in books on trade theory, such as Bhagwati *et al.* (1998) and Feenstra (2004), and in classic papers on the 2×2 model such as Jones (1965). For present purposes, I emphasize the results that are likely to be of most interest to growth economists.

Prime among these is the Rybczynski theorem, which in essence says that when the relative amount of one factor is increased, the relative output of the sector that uses that factor intensively will also increase. To put this in more concrete terms, as the capital–labour ratio increases, the output of the non-agricultural sector will increase relative to the output of the agricultural sector: a simple story about the origins of structural change. This idea can be extended to think about the process by which countries, as they accumulate capital, move up through a ladder of increasingly capital-intensive sectors, a point emphasized by Jones (2004).

However, Rybczynski effects are not wholly satisfactory as an account of development paths. A perhaps surprising implication of the 2×2 model is that, as long as the economy remains incompletely specialized, factor prices are independent of factor endowments.[9] For example, as capital is accumulated, wages do not increase. Aggregate output increases, as the sector with a higher average product of labour now accounts for a larger share of employment. Put differently, total capital income is rising. Nevertheless, the constancy of wages seems problematic for a theory of development. This limitation can be overcome by assuming a positive rate of technical progress or, more fundamentally, by generalizing the model to include a third factor, as in Leamer (1987).[10] For much of the remainder of this paper, however, a simple 2×2 structure will be enough to illustrate some of the points most relevant to growth economics.

[9]This result is well known among trade theorists. See, for example, Feenstra (2004, pp. 10–13). An extra complication is the possibility of factor intensity reversals, which are ignored here for simplicity.

[10]Another advantage of introducing a third factor is that the model can then be opened up to international flows of capital. In a simpler model, international capital mobility will often result in complete specialization in one of the two sectors.

Empirical analysis of the model described above is sometimes made easier by accounting identities. Denote the share of labour income in agricultural income by $\eta_a = w_a L_a / Y_a$ and in non-agricultural income by $\eta_m = w_m L_m / p Y_m$. The share of labour in total national income can be written as

$$\eta = \frac{w_a L_a + w_m L_m}{Y} \tag{9}$$

One result that is sometimes useful is to rewrite this equation as

$$\eta = \frac{Y_a}{Y}\frac{w_a L_a}{Y_a} + \frac{pY_m}{Y}\frac{w_m L_m}{pY_m} = s\eta_a + (1-s)\eta_m \tag{10}$$

In other words, the aggregate labour share is equal to a weighted average of the sectoral labour shares, where the weights are the shares of each sector in value added.

Under the assumption that wages are equal in the two sectors ($w_a = w_m = w$) the expression (9) can be simplified to $\eta = wL/Y$. This result can be used to rewrite the share of labour in agricultural value added as

$$\eta_a = \frac{wL_a}{Y_a} = \frac{wL}{Y}\frac{L_a}{L}\frac{Y}{Y_a} = \frac{a\eta}{s} \tag{11}$$

Similarly we can also derive an expression for the labour share in the modern sector:

$$\eta_m = \frac{1-a}{1-s}\eta \tag{12}$$

Hence we have two simple expressions for the sectoral factor shares, as functions of the agricultural output and employment shares, and the aggregate labour share. If we are also willing to assume constant-returns Cobb–Douglas technologies in the two sectors, the sectoral factor shares are equal to the exponents on labour. In that case, it is easy to infer sectoral technology parameters directly from observable data, as in Temple (2004). In the case of a known wage differential between the two sectors, (11) and (12) can be modified in a straightforward way.

The data on sectoral shares of value added may be especially unreliable for developing countries. When using these data, one way to carry out a sensitivity analysis is to follow Graham and Temple (2001) in assuming that a certain fraction of agricultural output is not measured in the national accounts, perhaps because it is used for self-consumption. Parente *et al.* (2000) and Gollin *et al.* (2004) analyse in more depth the mix of market and non-market activity in developing countries, using a structural model.

If the output and employment shares are used to infer technology parameters, or to make statements about relative productivity, an important

objection is that rural and urban labour should not be treated as homogeneous. This assumption can be difficult to relax, but one simple trick does allow the average quality of labour to be higher in the urban sector, while retaining the simplicity of the model above. Assume that there are N people in the economy, and that a fraction φ of these people are highly skilled, the rest unskilled. In the urban sector, those with skills supply a quantity of effective labour that is h times the effective labour input of the unskilled (which is normalized to one). The two types of labour are perfect substitutes at this fixed ratio, which means we can aggregate heterogeneous labour inputs in terms of efficiency units. In the context of the model above, it also means that, if the unskilled earn an urban wage w_{m} in equilibrium, the skilled will receive income of hw_{m}.

The labour input variables in the above equations (L, L_{a} and L_{m}) should now be interpreted as measured in efficiency units. The total amount of labour in effective units will be

$$L = [\varphi h + (1 - \varphi)]N$$

For simplicity, assume that the skilled only ever work in the urban sector. This assumption implies that a head-count measure of labour input, such as the agricultural share of employment, will overstate the share of the effective labour input that is allocated to agriculture, and understate the share allocated to the urban sector. As before, use $a = L_{\mathrm{a}}/L$ to denote the share of effective labour devoted to agriculture. The assumptions above can be used to relate this share to the observable variable, the head-count share, N_{a}/N, which will be denoted a_N. I assume that $\varphi < 1 - a_N$ so that the agricultural labour force is entirely unskilled. We then have

$$a = \frac{L_{\mathrm{a}}}{L} = \frac{a_N N}{[\varphi h + (1 - \varphi)]N} = \frac{a_N}{\varphi h + (1 - \varphi)}$$

and so a is now redefined as a measure of the share of efficiency units of labour allocated to agriculture. Given data on the variables φ (the ratio of skilled workers to total employment) and a measure of the relative productivity of the skilled (h), it is easy to move between the observed head-count allocation of labour and the (unobserved) proportion of efficiency units allocated to agriculture. Moreover, the efficiency units assumption, combined with constant returns to scale, implies that in most respects the model is essentially the same as the one described previously. This is a simple way to allow average human capital to differ systematically across the agricultural and non-agricultural sectors. It may be especially useful in simple calibration exercises, or level-accounting decompositions; see Caselli (2004) for a related approach in the latter context.

4 Wage Differentials and the Informal Sector

> It is difficult, therefore, to envisage that the productive potential of an economy is determined by the full employment of its labour force. The latter assumes that the labour force in a particular economic sector or area cannot be augmented by a re-allocation of labour between sectors or enterprises. Neither of these statements is true. (Kaldor, *Causes of Growth and Stagnation of the World Economy*, second lecture)

The model of the previous section perhaps becomes more interesting when we consider specific departures from it. One obvious departure is to assume that wages in the two sectors are not equalized. This could be due to a variety of reasons—migration restrictions, minimum wage legislation or trade unions in the urban sector, or a role for efficiency wages. The presence of a wage differential means that we replace the original equilibrium condition (7) with

$$w_{\mathrm{m}}/w_{\mathrm{a}} = d$$

In other respects, the structure of the simple two-sector model can be retained. This has led to analysis by trade theorists of small general equilibrium models with factor market distortions; classic contributions include Jones (1971), Magee (1973, 1976) and Neary (1978).

A natural justification for a wage differential would be a spatial separation between industry and services, located mainly in cities, and agriculture in rural areas. If the rural–urban migration process is not instantaneous, perhaps because of migration costs associated with spatial relocation, then any shock to productivity in one sector will generate a wage differential. The differential will only be eroded as potential migrants gradually respond to the difference in wages. Alternatively, a rural–urban wage differential could be an equilibrium phenomenon, as discussed in the Appendix.

If we assume that workers receive their marginal products, the wage differential implies that the marginal product of labour is not equalized between sectors. This has implications for aggregate growth. Reallocating labour to a sector where its marginal product is relatively high will raise aggregate output, in the absence of other considerations. Since total output has risen without any change in the total supplies of capital and labour, the increase in output also corresponds to an increase in aggregate total factor productivity. This effect will be discussed in more detail below. Weil (2004, pp. 284–289) provides an especially clear textbook discussion.

A potentially more interesting form of dualism arises when there is the possibility of urban unemployment (or underemployment). Here, a digression about less-developed country unemployment may be useful. It is well known that, in many developing countries, the absence of a formal welfare state means that unemployment is often a luxury—only those with liquid assets can afford to spend time out of employment. Instead, a substantial

fraction of the labour force is engaged in an informal sector, often in occupations where self-employment is possible and capital requirements are low. Estimates of the relative size of the informal sector for various countries suggest that it can easily account for as much as 30 per cent, or even more, of the total urban workforce.

How does the possibility of underemployment modify the previous analysis? For simplicity, I will refer to informal sector workers as 'unemployed'. If we denote the urban unemployed by L_u, our adding-up constraint on aggregate labour is modified as follows:

$$L_a + L_m + L_u = L \tag{13}$$

It is also useful to define the urban unemployment rate u as

$$u = \frac{L_u}{L_m + L_u} \tag{14}$$

We now need to rethink the intersectoral labour market equilibrium condition. A classic approach to this, due to Todaro (1969) and Harris and Todaro (1970), proceeds as follows. The first key assumption is that the urban wage is fixed above the market-clearing level, perhaps for institutional reasons such as minimum wage legislation or the presence of a trade union. This results in unemployment. For now, assume that the unemployed receive no income, and that workers are risk neutral.

The second key assumption is that workers will migrate between sectors unless expected utility is the same in each sector. Under risk neutrality, equilibrium occurs when the expected wage is the same in the two sectors. If we think about jobs in the urban sector being allocated by a lottery in each period, the expected urban wage is $(1 - u)w_m$ since $1 - u$ is the probability of holding an urban job. This means that our new labour market equilibrium condition is

$$(1 - u)w_m = w_a \tag{15}$$

In other respects, we can retain the structure of the 2×2 model described earlier, simply replacing (4) with (13), (7) with the Harris–Todaro condition (15), adding (14) and positing that the urban wage is exogenously fixed. This is the open economy version of the Harris–Todaro model developed by Corden and Findlay (1975).

The new equilibrium condition has some interesting properties. Above all, it can explain why rural–urban migration persists even in the face of high urban unemployment.[11] There are powerful general equilibrium effects at

[11]Of course, there are many important aspects of rural–urban migration that the model abstracts from, including remittances, decisions made at the level of households and various kinds of heterogeneity. See Stark (1991) and Lucas (1997) for deeper treatments of internal migration in developing countries.

work: e.g. a productivity improvement in non-agriculture may increase the extent of equilibrium unemployment, because the improvement in urban prospects generates extra rural–urban migration. This gives rise to the 'Todaro paradox', when employment creation is not accompanied by any decline in urban unemployment.

The simplicity of the Harris–Todaro model, combined with the richness of its implications, has led to much further research. The equilibrium condition (15) can be generalized in various ways—e.g. to allow for income even in unemployment, perhaps gained in the informal sector; for risk aversion, as in Collier (1975); and for on-the-job search, as in Fields (1989). These models typically retain the implication of an urban wage premium that is increasing in the extent of urban unemployment. Sometimes, this implication is strengthened: e.g. risk aversion will increase the wage differential associated with any given unemployment rate.

Not all versions of the model generate the Todaro paradox. Brueckner and Zenou (1999) consider a version of the Harris–Todaro model in which land rents play an equilibrating role. Migration to the city raises the cost of urban living by driving up rents, and this effect limits the migration response to an improvement in urban productivity. In their model, this effect is sufficiently powerful that the Todaro paradox is absent.

The original Harris–Todaro assumption that the urban wage is fixed can be unattractive in some contexts. A number of famous papers consider two-sector models in which the urban wage is endogenous; e.g. Calvo (1978) allows the urban wage to be influenced by trade union bargaining. Stiglitz (1974, 1976, 1982) considers efficiency wage explanations that give rise to models with similar properties.

In another interesting analysis, Bencivenga and Smith (1997) develop a model with two types of workers who differ in their productivity, and allow for an adverse selection problem in the urban labour market. In equilibrium, only the relatively productive workers are employed in the urban sector. In a special case of their model, where the unskilled earn no income when unemployed, the equilibrium urban unemployment rate satisfies a condition of the form (15), although the interpretation is now slightly different: w_a is the wage earned in agriculture by the unskilled, and the urban wage is endogenous. If this equilibrium condition is satisfied, unskilled workers will be indifferent between the two sectors, and are then assumed to work in agriculture. A separate indifference condition, slightly more complicated, holds for the skilled.

Note that the Harris–Todaro equilibrium typically implies a differential in the marginal products of labour between the two sectors. As before, aggregate output and TFP will be lower than in the first-best allocation, in which marginal products are equalized. This time, the effect of the differential in marginal products will be reinforced by the underemployment of some of the labour force. From the perspective of growth economists, interested in the

determinants of aggregate TFP, the magnitude of the output losses associated with factor misallocation and underemployment is worthy of study. This question has been addressed in different ways by Johnson (1966), Temple (2004) and Vollrath (2004).

Temple (2004) considers the output losses associated with both a simple wage differential and the Harris–Todaro equilibrium, in models of the form described above. The paper considers an urban unemployment rate of 30 per cent, corresponding to a non-agricultural wage that is about 40 per cent [≈1/(1 – 0.3) – 1] higher than the wage in agriculture. For wage differentials of this size, the analysis in Temple (2004) suggests that the gains from moving to the first-best allocation are not sizeable, and are often below 5 per cent of GDP. A more interesting result is that, in moving from the dualistic equilibrium to the first-best, the relative shares of the two sectors in output and employment can change substantially, especially when the elasticity of substitution in production is high. This suggests that the origins of a relatively small non-agricultural sector might be traced at least partly to the urban labour market—a point to which I shall return.

Much larger effects of factor misallocation are obtained in Vollrath (2004), who seeks to calculate the deadweight burden of misallocation for a large number of the world's countries. The difference in results arises for at least two reasons. First, Vollrath's calibration procedure allows wage differentials between the two sectors to be relatively high for a subset of the countries. Second, Vollrath also allows for misallocation of capital between the two sectors. This is an important point, as Fishlow and David (1961) established that distortions in the labour and capital markets can potentially interact in such a way that overall deadweight losses are magnified.

This raises a central problem in gauging the effects of misallocation, and in applying dual economy models to the data. It is difficult to obtain reliable estimates of capital stocks at the sectoral level for most developing countries.[12] The approach used by Temple (2004), in calculating deadweight losses for a stylized Harris–Todaro economy, is to assume that capital is perfectly mobile between the two sectors. It turns out that the intersectoral allocation of capital can then be written as a function of potentially observable variables, and without the need for capital stock data. Briefly, we are interested in solving for $x = K_a/K$, the fraction of capital allocated to agriculture. To start with a simple example, assume that there is no wage differential ($d = 1$). Then we can write the agricultural output share as follows:

$$s = \frac{Y_a}{Y} = \frac{wL_a + rK_a}{Y} = \frac{awL + rxK}{Y} = a\eta + x(1-\eta) \tag{16}$$

[12]The leading data set on capital stocks for agriculture and manufacturing is that described in Larson *et al.* (2000).

where $\eta = wL/Y$ is the aggregate labour share and hence $1 - \eta$ is the aggregate capital share. Equation (16) implies that we can compute x using data on agriculture's share of output (s) and employment (a) and the aggregate labour share:

$$x = \frac{s - a\eta}{1 - \eta} \tag{17}$$

Note that this calculation is valid regardless of the form of the production functions, as long as they have constant returns; in particular, it is not necessary to assume they are Cobb–Douglas. A more general version of expression (16) allows for a wage differential, in which case we have

$$x = \frac{s}{1-\eta} - \frac{a\eta}{(1-\eta)[a + d(1-a)]}$$

Typically, calculations of the intersectoral capital allocation using this method suggest that relatively little capital is employed in agriculture, but this finding can be sensitive to the assumption made about the intersectoral wage differential d.

In gauging the effects of factor misallocation, the lack of sectoral capital stock data is not the only problem. Uncertainty also surrounds the plausibility of different assumptions about the magnitude of intersectoral wage differentials in developing countries. Temple (2004) and Vollrath (2004) discuss some of the microeconomic evidence on this point. The evidence is clouded by the obvious need to control for worker characteristics, such as educational attainment, but does suggest that the urban wage can be as much as double the rural wage (Squire, 1981). Note that even microeconomic data on wages might be misleading about marginal product differentials, if workers are not paid their marginal product. This adds to the interest of exercises such as Robinson (1971), where some attempt is made to estimate the size of marginal product differentials from cross-country data, as will be discussed below.

An alternative approach relies on more sophisticated computable general equilibrium models, as in the applied literature on international trade. Such models have been used to study the effects of wage differentials in Dougherty and Selowsky (1973), de Melo (1977) and Williamson (1987, 1989). These models allow a substantial gain in realism, but also have some disadvantages. Above all, there is the usual 'black box' problem. It is not always clear which parameter assumptions are driving the results, or whether the findings would generalize to other cases. The extra complexity of the computable general equilibrium models also makes it hard to interpret the results using standard trade theory.

Although the computable general equilibrium literature is vast, labour markets are rarely considered in detail. Most contributions focus on the

interactions with trade policy, as in Devarajan *et al*. (1997, 1999), Maechler and Roland-Holst (1997) and Thierfelder and Shiells (1997). There are surprisingly few studies of the aggregate effects of labour market distortions, even though this could be interesting in its own right. Section 10 below will discuss this point in greater detail.

5 Dual Economies with Increasing Returns

So far, attention has been limited to cases where returns to scale in both sectors are constant. An obvious modification to the dual economy model is to introduce increasing returns in one of the sectors. In the early years of development economics, it was often assumed that returns to scale in the modern, industrial sector might be increasing. A leading proponent of this view was Kaldor (1966), who argued that Europe's fast post-war growth was made possible by increasing returns in industry, combined with an abundant supply of labour from the agricultural sector (see also Kindleberger, 1967; Cornwall, 1977). There have been surprisingly few attempts to capture these ideas formally. Canning (1988) is a rare example of a multisector growth model with increasing returns, and has clear echoes of Kaldor. A more general discussion of Kaldor's ideas, and their relation to the earlier work of Lewis (1954), can be found in Ros (2000).

It is easy to see why the increasing returns case is less intensively studied than constant returns. Capturing the effects of increasing returns in simple formal models, while retaining some degree of generality, is difficult. The best-known models, such as Murphy *et al*. (1989a, 1989b), are illuminating but proceed under restrictive assumptions about technologies and market structure. This can also limit the usefulness of the models in terms of generating testable implications.

When modelling increasing returns, a useful trick has often been to assume that individual firms use constant-returns technologies, while an externality ensures that returns are increasing at a more aggregate level, such as a particular sector or the whole economy. The celebrated paper on endogenous growth by Romer (1986) is one of the best-known examples of this device (see also Cannon, 2000). The strength of the externality assumption is that one can continue to assume perfect competition and marginal productivity factor pricing, rather than making alternative and often rather specific assumptions about technologies, firm competition and preferences.

This suggests using the same trick in the context of a two-sector general equilibrium model of production. In the trade theory literature, this is an instance of the 'variable returns to scale' (VRS) model. Choi and Yu (2002) provide an overview of work in this tradition. Again, the model is typically one of a small open economy, in which both goods can be traded on world markets. The remainder of the model is completely described by the adding up constraints on the factors and total output; the production technologies;

factor market equilibrium conditions; and equality between factor prices and marginal products. Note that, with increasing returns arising through an externality, factor prices will be equal to private marginal products in a decentralized allocation, and not equal to the social marginal products.

If labour is reallocated from the non-increasing returns sector to that with increasing returns, there are now potentially richer effects associated with reallocation. As before, there may be a difference between the two sectors in terms of wages and the private marginal product of labour; but even in the absence of this, reallocations can raise aggregate output. This is because reallocating labour to non-agriculture increases the scale of the sector and, given increasing returns, thereby raises its productivity.

Graham and Temple (2001) study these effects, and another potential consequence of the VRS assumptions—namely, the possibility of multiple equilibria. Consider a model with capital and labour in non-agriculture, and capital, labour and land in agriculture. Under the assumption that both labour and capital are mobile between the two sectors, this simple structure typically results in three production equilibria: one with complete specialization in agriculture, and two with incomplete specialization that both satisfy the factor market equilibrium conditions. Naturally, these equilibria differ in the allocations of labour and capital across sectors, and in aggregate output. Although this may seem complicated, the model is simple to work with, and generates sharp predictions. For example, Graham and Temple (2001) derive a condition that can be used to infer whether a given country is in a low-output equilibrium or a high-output equilibrium. It is also possible to compute the allocation of employment and capital that would obtain in the other (interior) equilibrium, and quantify the output gains from switching between equilibria.

There are perhaps two main weaknesses of the VRS model in this context. The first is that one of the equilibria with incomplete specialization will be locally unstable under standard assumptions about the out-of-equilibrium adjustment process. This is especially problematic for an empirical analysis, because a locally unstable equilibrium is unlikely to be observed in the data. Graham and Temple (2001) show how this problem can be overcome with an alternative set of assumptions. Nevertheless, in an account of the development process, one might seek a model with greater generality.

A second limitation of the VRS model relates to its starting point: the assumption of increasing returns. By definition, this leads to scale effects. The productivity of a given sector, or even the whole economy, should be positively related to a measure of scale (e.g. the size of the workforce). Graham and Temple (2001) briefly review the empirical literature on these scale effects. It is not clear that they arise at the aggregate level, not least because a number of relatively small economies are highly productive (Hong Kong and Singapore, for example). There may be more hope of finding scale effects that work through the size of the non-agricultural sector, but this issue has yet to be

investigated in depth. At a broader level, the tendency for economic activity to cluster in particular locations does suggest that returns are increasing over some level of production, while Antweiler and Trefler (2002) use evidence from trade flows to infer mild increasing returns in certain sectors. Whether these effects are sufficiently powerful to be central to the development process remains an interesting open question.

6 Levels Accounting in Dual Economies

An important development in recent growth research has been the application of accounting decompositions to the level of output. The basic idea is straightforward: given an aggregate production function, and the assumption that factors are paid their marginal products, one can measure aggregate TFP for most of the world's economies. It is then possible to examine the international variation in levels of TFP, and its contribution to the variation in output per worker. This line of research is especially associated with Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999) (see also Prescott, 1998; McGrattan and Schmitz, 1999).

Most implementations of this idea are based on a one-sector model and assume that different countries have the same factor shares. As we have seen, the dual economy perspective casts doubt on the usefulness of these assumptions. This observation has led to a literature on levels accounting and productivity measurement in dual economies, led by Chanda and Dalgaard (2003), Restuccia *et al.* (2003) and Caselli (2004). The richer structure of a dual economy model has some major advantages, including the ability to construct measures of TFP levels for each sector, agriculture and non-agriculture. It would surely be interesting to know whether the international variation in aggregate output per worker is mainly due to low agricultural productivity in developing countries, or low productivity in non-agriculture.

There are at least two problems in pursuing this route, however. The first is the lack of capital data at the sectoral level. A possible solution is to use the trick described earlier, namely to use the assumption of intersectoral capital mobility to back out the allocation of capital using data on output and employment shares.

A second problem is that, to compare sectoral productivity levels across countries, one needs measures of real output in each sector that are comparable across space—to put this differently, purchasing power parity adjustments are necessary. To see this, say that we write nominal output as

$$Y = p_{\mathrm{a}}Y_{\mathrm{a}} + p_{\mathrm{m}}Y_{\mathrm{m}}$$

using an obvious notation. Define real output as

$$Y' = \frac{p_{\mathrm{a}}Y_{\mathrm{a}} + p_{\mathrm{m}}Y_{\mathrm{m}}}{P(p_{\mathrm{a}}, p_{\mathrm{m}})}$$

where P is an aggregate price index with the usual properties (e.g. it should be homogeneous of degree one). The value added shares we observe in the data correspond to

$$s = \frac{p_a Y_a}{p_a Y_a + p_m Y_m}$$

Note that if we simply calculate agricultural output using the domestic price output share and a measure of aggregate real output (using $s \times Y'$) we will obtain

$$sY' = \frac{p_a Y_a}{P(p_a, p_m)} = \frac{Y_a}{P(1, p_m / p_a)}$$

rather than real output Y_a. This will tend to distort international comparisons of productivity levels unless the relative price of agriculture is similar in different countries. We need either to deflate sectoral nominal output, using price data to compute an appropriate price index, or to evaluate output for a given sector using prices that are the same in all countries ('international prices'). Restuccia *et al.* (2003), using data from the FAO on agricultural producer prices, have implemented such an adjustment for 1985 (see also Caselli, 2004). Their calculations reveal that the international variation in agricultural productivity is much greater once purchasing power parity adjustments are made.

International productivity comparisons typically assume that returns to scale in non-agriculture are constant, but it is easy to extend the ideas to the VRS model described in the previous section. For example, the usual decompositions can be derived as a straightforward extension of the calculations in Graham and Temple (2001). The main difference in the VRS case is that the possibility of multiple equilibria has to be incorporated in the analysis.

7 Growth in a Dual Economy

So far, the analysis has been static, in the tradition of trade theory. As argued in the introduction, comparisons of static equilibria can have interest for growth economists, and it is a mistake to think that we can learn about productivity levels only by using a dynamic model. Nevertheless, it is interesting to consider how analyses of aggregate growth might be modified in the case of a dual economy. I will draw on the discussion and derivations in Temple (2001) and Temple and Woessmann (2004).

A brief digression on structural change may be useful at this point. Dynamic analyses of dual economies are sometimes used in attempts to quantify the overall effect of structural change on growth. This seems natural, because changes in the sectoral allocation of labour allow growth to take place. In their absence, disequilibrium across sectors would steadily increase, and output would be lower than in the case of smooth adjustment. However,

structural change is an endogenous process, driven by sectoral productivity growth, income elasticities of demand, changes in factor endowments and world prices, and possibly even switches between multiple equilibria. Given that sectoral structure is clearly a general equilibrium outcome, to ask the question 'What is the growth effect of structural change?' can be too much like asking 'What is the growth effect of equilibrium prices and quantities?'.

This suggests that attempting to measure the growth effects of structural change is a mistaken endeavour. This section considers two alternative questions that are narrow but precisely defined. First, what is the relationship in dual economies between growth in output per worker and input growth? Second, what is the direct contribution of labour reallocation to aggregate TFP growth, in economies that are characterized by sizeable differentials in the marginal product of labour? These questions require us to extend standard growth accounting decompositions to dual economies.

The results are easiest to develop in continuous time. I start with the case where there is no wage differential, which allows a simple treatment of price changes. The results for a dual economy are then a special case of those in Jorgenson and Griliches (1967). In particular, using Divisia indices for quantities and prices leads to the following expressions for aggregate TFP growth:

$$\frac{\dot{A}}{A}=\frac{\dot{Y}}{Y}-[1-\eta(t)]\frac{\dot{K}}{K}-\eta(t)\frac{\dot{L}}{L}=s(t)\frac{\dot{A}_{\mathrm{a}}}{A_{\mathrm{a}}}+[1-s(t)]\frac{\dot{A}_{\mathrm{m}}}{A_{\mathrm{m}}} \tag{18}$$

where $\eta(t)$ and $s(t)$ are the aggregate labour share and agricultural output share, respectively, and depend on time. In particular, given the two-sector structure of the model, the aggregate factor shares will tend to vary across countries and over time, even if the sectoral production functions are both Cobb–Douglas. This is because the aggregate factor shares will be weighted averages of the sectoral factor shares, with weights equal to the shares of each sector in total value added, as in equation (10) above.

The final equality in (18) shows that aggregate TFP growth is a weighted average of TFP growth in the two sectors, where the weights are equal to the time-varying shares of the sectors in total value added. This simple result arguably deserves more attention than it receives in the empirical growth literature.[13] As noted in Section 1, empirical work on growth has often assumed that efficiency growth is the same across countries, on the assumption that technologies can be easily transferred across national borders. In a two-sector world, the constancy of efficiency growth no longer follows from the possibility of technology transfer, except in unlikely special cases.[14]

[13]It can be seen as a special case of the more general principles of Domar aggregation. See, for example, Jorgenson and Stiroh (2000).

[14]In principle one could imagine a long-run equilibrium in which all countries converge to the same sectoral structure. Such a long-run outcome is unlikely to be relevant over the time spans considered in most growth regressions, however. For relevant empirical work, see Wacziarg (2001) and Imbs and Wacziarg (2003).

How are these results modified in the presence of a wage differential? Temple (2001) and Temple and Woessmann (2004) derive expressions analogous to (18), treating relative prices as fixed over time within each economy and assuming a wage differential between the two sectors:

$$w_m / w_a = d$$

Temple (2001) shows that aggregate TFP growth is then given by

$$\frac{\dot{A}}{A} = s\frac{\dot{A}_a}{A_a} + (1-s)\frac{\dot{A}_m}{A_m} + \frac{(d-1)m}{1+(d-1)m}\eta\frac{\dot{m}}{m} \tag{19}$$

where m is the share of non-agricultural employment in total employment (or $m = 1 - a$). The final term is the 'growth bonus' obtained by reallocating labour to a sector where its marginal product is higher. Hence this expression reveals the contribution of labour reallocation to aggregate TFP growth, in the presence of a marginal product differential $d \neq 1$. This effect of labour reallocation is essentially that examined by Kuznets (1961) and Denison (1967, 1974), and briefly discussed in Barro (1999). The result can be used as the basis for either growth accounting, in which an assumption is made about the differential, or growth regressions, in which d would typically be estimated from the data.

The main drawback of the growth accounting approach is that, in the absence of good data on wages by sector, the magnitude of the intersectoral wage differential is typically based on an educated guess, as in Denison (1967). In this regard, the specific form for the equation given in (19) makes clear an interesting property, noted in Temple (2001). As the wage differential d tends to infinity, the reallocation effect approaches an upper bound given by $\eta\dot{m}/m$. This is a natural consequence of the current assumptions. Allowing the differential d to tend towards infinity corresponds to a finite upper bound on the marginal product in non-agriculture (equal to the non-agricultural wage) and an agricultural marginal product approaching its lower bound of zero. As a result, the effect on TFP growth of transferring labour from one sector to the other must have an upper bound, even as the ratio of marginal products becomes very high.

Sometimes, more precision in measuring the reallocation effect may be desirable. Using accounting identities similar to those discussed in Section 3, Temple (2001) shows that bounds on the sectoral factor shares, combined with knowledge of the aggregate labour share, can be used to place bounds on the intersectoral wage differential. In some circumstances, this is a promising approach, but the paucity of data on sectoral factor shares for developing countries limits its usefulness in that context.

An alternative approach is to incorporate marginal product differentials into cross-country growth regressions, as in the pioneering studies by Robinson (1971) and Feder (1983, 1986). In this approach, the researcher includes the structural change term as an explanatory variable in a regression, and

estimates its coefficient from the data. This removes the need for guesswork about the extent of differentials, at the expense of introducing a host of other problems. One drawback is that the wage differential may take very different values for different countries.

Temple and Woessmann (2004), prompted by a suggestion of Bryan Graham, introduce a more complex idea. Their paper describes a set of assumptions under which the cross-country relationship between growth and the extent of structural change will be convex rather than linear. The intuition is fairly straightforward. If wages are roughly equal to marginal products, the growth bonus associated with structural change is increasing in the size of the intersectoral wage differential. If we had to guess which countries have the largest wage differential, we might well guess those countries in which the observed extent of structural change is most rapid, reflecting large private gains from switching sectors. Conversely, in countries where structural change has recently slowed down, such as the major economies of Western Europe, we might infer that wage differentials have been virtually eliminated. But this implies that the growth impact of a given extent of structural change will be the greatest in those countries experiencing more rapid structural change, because these are also the countries, at least on average, in which the intersectoral differential is greatest.

At the aggregate level, this translates into a convex relationship between structural change and growth in the international cross-section. Temple and Woessmann (2004) find some evidence for this convex relationship in the data. Their estimates suggest that, for some countries, the differentials are similar in magnitude to the rural–urban wage gaps observed in microeconomic data. Another finding is that labour reallocation can account for a significant fraction of the international variation in TFP growth.

An alternative strategy, adopted by Dowrick and Gemmell (1991) for growth regressions and by Restuccia *et al.* (2003) for a calibration, is to use the ratio of average productivity in the two sectors as a proxy for the differential in marginal products. The justification for this is that, as we saw previously, if technologies in the two sectors are Cobb–Douglas, the ratio of marginal products is proportional to the ratio of average products. This approach clearly has much to recommend it, at the expense of more restrictive assumptions about the production technologies. Another disadvantage, specific to growth regressions, is that it requires the use of additional data on sectoral output shares. As discussed previously, the output share data may be especially unreliable.

These frameworks could be extended in several ways. The main challenge is to incorporate migration decisions that are forward-looking in models that remain simple enough to take to the cross-country data. Matsuyama (1992a) and Lucas (2004) provide elegant approaches to sectoral adjustment that might form the basis for further work. In the Lucas model, human capital has to be accumulated in cities, and in a migration equilib-

rium the return to this human capital accumulation is equal to the rural wage. There may be scope for applying simpler versions of this idea to cross-country data.

Perhaps more fundamentally, the study of the relationship between TFP growth and factor reallocation is clearly only a single facet of structural transformation, and there are many other issues of interest. A wider-ranging treatment can be found in the classic empirical studies by Chenery and Syrquin (1975) and Chenery *et al.* (1986). Kim and Topel (1995) is an interesting empirical study of how labour markets and growth interacted in the course of Korea's industrialization and structural transformation. Other relevant papers include Echevarria (1997), Atkeson and Kehoe (2000), Galor and Weil (2000), Laitner (2000), Caselli and Coleman (2001), Kongsamut *et al.* (2001), Gollin *et al.* (2002a, 2002b), Hansen and Prescott (2002) and Ngai and Pissarides (2004). These papers show how multisector models might contribute to our broader understanding of growth, something that will be explored in the next section.

8 From Lewis to Solow

One drawback of two-sector models is that a dynamic analysis can be relatively complicated. This perhaps explains why most growth textbooks devote relatively little attention to dual economy models. From a theoretical point of view, it is well known that stability in the neoclassical two-sector model of Uzawa (1961, 1963) requires specific conditions that are hard to investigate empirically.

In models of the form considered above, another relevant issue is the speed of intersectoral adjustment relative to the rates of factor accumulation. For example, Bartlett (1983) showed that the Harris–Todaro equilibrium is only saddle-path stable (at best) when the intersectoral allocation of labour is treated as a state variable, rather than adjusting instantaneously. Kanbur and McIntosh (1988) discuss his results, and emphasize the importance of relative adjustment speeds for understanding the long-run properties of dual economy models. At the same time, there are dangers in taking too literally the long-run outcome of a dual economy model: ideally that analysis would require the extent of dualism to be treated as endogenous, as discussed by Kanbur and McIntosh.

From an intellectual point of view, it would be satisfying to have a growth model that integrated the experience of developed and developing countries, in the same way that papers such as Galor and Weil (2000) and Hansen and Prescott (2002) have used multisector models to integrate the modern-day experience of developed countries with their historical past. A particularly attractive framework would be one in which current low-income countries eventually come to follow the growth path of the one-sector neoclassical model, as in Gollin *et al.* (2002a).

With this in mind, this section will discuss one of the versions of the Lewis (1954) model considered by Dixit (1973).[15] This provides an especially simple account of a growth process in which developing countries undergo a structural transformation before finally converging to the balanced growth path of a one-sector Solow model. To set out the basic ideas, continue to assume a small open economy with two sectors and fixed commodity prices. Factors receive their marginal products. The main departure from the previous analysis is that we restrict the production functions. In particular, we assume a production function in agriculture that is linear in a single input, labour:

$$Y_{\mathrm{a}} = A_{\mathrm{a}} L_{\mathrm{a}} \tag{20}$$

This linearity assumption will be discussed later. The production function in non-agriculture is constant elasticity of substitution:

$$Y_{\mathrm{m}} = \left[\delta K^{-\rho} + (1-\delta)(A_{\mathrm{m}} L_{\mathrm{m}})^{-\rho}\right]^{-1/\rho}$$

where the elasticity of substitution $\sigma = 1/(1 + \rho)$. This model has a number of interesting implications, which I will now sketch, drawing on Mundlak (2000) and Temple (2005b).

First of all, the agricultural production function ties down the wage in the two sectors ($w_{\mathrm{a}} = w_{\mathrm{m}} = A_{\mathrm{a}}$) and, in particular, this wage is determined independently of the allocation of labour across sectors. From the standard properties of production functions with constant returns to scale, the exogenous wage determines the capital–labour ratio in non-agriculture, and the rental rate of capital (r). Then, directly from the aggregate value added identity, it must be the case that output per worker is equal to

$$\frac{Y}{L} = w + \frac{rK}{L} = A_{\mathrm{a}} + r(A_{\mathrm{a}}, A_{\mathrm{m}})k \tag{21}$$

where k is the aggregate capital–labour ratio, and the dependence of the rental rate on the technology parameters is made explicit. This can be interpreted as an indirect or composite production function that is linear in the capital–labour ratio, but with a positive intercept that depends solely on agricultural productivity; Mundlak (2000, p. 210) draws attention to this relationship. It can also be shown that, beyond a threshold level of the aggregate capital–labour ratio, the agricultural sector closes down and we are back in the world of the one-sector Solow model, with a constant elasticity of substitution aggregate production function.

The real interest rate is constant throughout the 'Lewis phase' of the model, in the absence of technical progress. This model provides an alternative way to illustrate the important point made by Robertson (1999), namely

[15]The Lewis paper appeared in this journal in 1954. For a review of the issues raised by his famous paper, 50 years on, see the December 2004 issue of *The Manchester School*.

that a two-sector model can help to explain why the return on capital does not decline sharply as development proceeds.[16] Otherwise, it is hard to explain why economies in which capital intensity has sharply increased—such as Japan, or the miracle economies of East Asia—have not seen substantial falls in the real interest rate. Robertson (1999) discusses this issue in more detail.

This 'Lewis–Solow' model has some other interesting properties. Whether it arises from a Lewis model or more generally, the relationship shown in (21) might also explain why the correlation between output and capital observed in the data—and especially, data for developing countries—typically indicates that returns to capital diminish less sharply than expected. It could therefore be an alternative explanation for some of the empirical findings in Mankiw, Romer and Weil.

In the Lewis phase, the wage is independent of labour demand in the non-agricultural sector. For this reason, discussions of the model have often focused on historical examples in which wages may have been slow to rise despite rapid growth in aggregate productivity (Fields, 2004). More generally, wages can rise even in the Lewis phase, if productivity is rising in the agricultural sector. This case is interesting, because the Green Revolution in agriculture had a major impact in countries well suited to the new crop varieties and other innovations in agricultural technology. Dixit (1973) argued that the assumption of exogenous technical change in agriculture was unattractive for labour-surplus economies. In retrospect that argument perhaps carries less weight, especially when fitting models to historical data, since the Green Revolution can be seen as a sizeable exogenous technology shock.

These considerations suggest that there is a case for revisiting the Lewis model. Gylfason and Zoega (2004) use a similar structure to develop a model in which the distance of economies from the world technology frontier partly depends on characteristics of the agricultural sector. Temple (2005b) develops a variant of the Lewis model, which allows different rates of technical progress in the two sectors. The model makes interesting predictions that can be tested against cross-country data. For example, it is easy to derive implications for the path taken by relative labour productivity in the two sectors.

There is another appealing feature of the integrated Lewis–Solow model. At least relative to some of the other dual economy models, it will be easier to introduce a dynamic analysis, including capital accumulation. One route is to extend a Ramsey-type analysis to the two-sector case, as in Dixit (1968)

[16]The result obtains in more general 2×2 models, given that the return to capital will be independent of the capital–labour ratio while the economy remains incompletely specialized. The more general formulations, however, have the property that when the capital–labour ratio is very low all capital and labour will be devoted to the agricultural sector, and the rental rate on capital will decline as capital is accumulated until the non-agricultural sector also starts to produce output.

and Stern (1972). The endogenous transition from the Lewis phase to the Solow phase introduces a technical challenge, but there is also a deeper conceptual problem, namely whether a representative agent assumption is appropriate for a dual economy. At least as a positive theory of the evolution of the saving rate, it may be useful to return to the classical (and Pasinetti–Kaldor) assumption that saving rates differ across capital income and labour income. Stiglitz (1967) and Dixit (1973) consider the implications for analysis of capital accumulation in dual economies.

Although the above version of the Lewis model is relatively simple to analyse, this simplicity partly depends on the linearity of the agricultural production function, equation (20) above. In contrast, cross-country estimates of agricultural production functions, such as those in Hayami and Ruttan (1985), tend to suggest that returns to labour in agriculture are diminishing. The usefulness of the Lewis model, at least as a framework for empirical growth economics, then lies mainly as an approximation to economies in which agriculture is highly labour intensive. Alternatively, the idea of a linear, labour-only production function could be applied to an informal sector rather than agriculture, an idea that will be discussed further below.

Another interesting variant on the model arises when the production function in non-agriculture has increasing returns, arising through an output-generated externality. Then, the model combines elements of Lewis (1954) and Kaldor (1966) (see also Ros, 2000). The presence of increasing returns can generate a Verdoorn's law relationship between productivity growth in non-agriculture and the rate of growth of non-agricultural employment, of the form emphasized by Kaldor.

More generally, it is possible to derive growth accounting relationships that apply in such an economy, maintaining the small open economy assumption. As before, there is an effect of reallocating labour from agriculture to non-agriculture in the presence of a marginal product differential. But with increasing returns, the growth in aggregate output per worker will also be related to the expansion of the non-agricultural capital stock and employment, because increases in the scale of the non-agricultural sector will raise its productivity. In practice, applying such a growth accounting decomposition to this Lewis–Kaldor model is limited by the availability of sectoral capital stock data, but it is an interesting area for further work. For more general models, such as those described in Section 5, multiple equilibria may arise and growth accounting methods then have to be applied with caution.

9 Related Models

So far, most of the analysis has focused on the small open economy case, in which both goods can be traded. This section briefly considers some variants on this theme, including a perfect substitutes assumption, a closed economy

and the 'Australian' model of a dependent economy incorporating a non-traded sector.

One assumption sometimes made in theoretical work on two-sector models is to consider a closed economy but make the two goods perfect substitutes, as in Robertson (1999) and Hansen and Prescott (2002) for example. This assumption means that much of the above analysis applies, but both goods are priced at unity, avoiding the need for price indices and simplifying consideration of intertemporal aspects of the model. Mundlak (2000) calls this the 'coexistence of techniques' assumption, since effectively what is being modelled is the coexistence of a traditional, labour-intensive sector and a modern sector that has access to a more capital-intensive technology for making the same good.

The perfect substitutes assumption makes the interpretation of the two sectors as agriculture and non-agriculture less appealing, but casts an interesting light on the Lewis model. It can then be interpreted as a model of a formal and informal sector, producing the same good, but where production in the informal sector makes no use of capital. This model is attractive in several ways, its main disadvantage being that it is hard to implement empirically, since we know relatively little about the relative size of the formal sector in terms of employment and (especially) output shares. Landon-Lane and Robertson (2003) implement the model empirically by using the extent of child labour as a proxy for the size of the informal sector.

A more complex departure is to consider an economy that is entirely closed to trade. From an analytical point of view, this can be seen as a modification of the open economy case, with an additional endogenous variable (the relative price) and an extra equation, often provided by maximization of utility by a representative consumer. In specifying preferences, most authors wish the share of agricultural goods in household expenditure to decline as development proceeds, and so a common choice is Stone–Geary:

$$U(c_{\mathrm{a}}, c_{\mathrm{m}}) = \beta \log(c_{\mathrm{a}} - \gamma) + \log(c_{\mathrm{m}})$$

where c_{a} is consumption of the agricultural good, c_{m} is that of the non-agricultural good, and the parameter $\gamma > 0$ ensures that the expenditure share of agriculture declines with income. A number of papers use this specification, including Matsuyama (1992b, 1992c), Caselli and Coleman (2001) and Gollin *et al.* (2004). Eswaran and Kotwal (1993) and Gollin *et al.* (2002a) consider a more extreme version, in which all income below a certain threshold is spent on the agricultural good, and any income above the threshold is spent entirely on the non-agricultural good. For example:

$$\begin{aligned} U(c_{\mathrm{a}}, c_{\mathrm{m}}) &= \log(c_{\mathrm{m}}) + \gamma \quad && \text{if } c_{\mathrm{a}} \geq \gamma \\ &= c_{\mathrm{a}} && \text{otherwise} \end{aligned}$$

These hierarchical preferences allow a simple analysis of an important issue for a closed economy, namely how quickly the agricultural sector can release

labour while still meeting the population's food requirements. Analysis of this problem, which is absent in the open economy case because of the ability to import food, has a long history in the dual economy literature (see Kanbur and McIntosh (1988) and Ranis (1988) for more discussion). The natural assumption that production of food is essential can have important consequences. One possibility is that the poor spend their budget entirely on food: as a result, productivity growth in the non-agricultural sector may not improve the lot of the poor. Eswaran and Kotwal (1993) explore this idea in more detail.

In terms of realism, the polar cases of the small open economy and the wholly closed economy are often less appealing than a model with traded and non-traded goods. In this respect, the 'Australian' or dependent economy model, with an export sector, an import-competing sector and a non-traded sector, is especially attractive. It is sometimes applied in work using computable general equilibrium models, and Agénor (2004) discusses an approach that combines the dependent economy model with some of the labour market issues already discussed. As a framework for empirical studies and growth economics, the main drawback of the Australian model is its complexity. The richness of the model exerts the usual price, in that it is more difficult to analyse than the 2×2 models that have formed the basis for much of this review. Nevertheless, just as the one-sector model often stands in the way of a two-sector approach, it would be unfortunate if the simplicity of dual economy models always stands in the way of a more detailed analysis, as Kanbur and McIntosh (1988) emphasize.

10 Labour Markets and Growth

A point made briefly in passing is that, where countries have a relatively small non-agricultural sector, the explanation may lie partly in the nature of the urban labour market. This section generalizes this argument, to emphasize that the two-way interactions between growth and labour markets are not sufficiently well understood. The need to remedy this omission has been stressed by many observers, including Freeman (1992) and Agénor (1996, 2004). However, it remains a vital missing link in the growth literature, especially from the viewpoint of any government faced with widespread underemployment, growth that does not absorb labour or rising wage inequality.

At first sight, the nature of labour markets in multisector models may not seem fundamental to growth economics. However, consider the issues that can be studied in this way. First of all, one might be interested in whether various imperfections in labour markets have consequences for aggregate outcomes, like sectoral structure or productivity (Temple, 2004). Second, these models allow different types of growth—e.g. capital accumulation and

technical progress in the agricultural sector, the urban formal sector, and within the informal sector. Third, multisector models are needed to examine the effects of growth on urban underemployment and the size of the informal sector, a key policy issue in many developing countries. A general equilibrium model allows a meaningful discussion of the concept of labour-intensive growth, something that is difficult in the one-sector, full-employment world of the standard textbook models. Fourth, a framework with several sectors, and a more detailed specification of the labour market, allows a much richer account of the interactions between growth and inequality. Overall, since the main source of income for the poor will usually be labour income, consideration of the interactions between growth and labour markets will be critical to understanding the origins of pro-poor growth (Agénor, 2004).

Clearly, to think about these issues carefully requires a general equilibrium approach. Temple (2005a) shows how the Harris–Todaro model can be used to investigate the effects of different types of growth on overall wage inequality, incorporating general equilibrium effects. This approach may give some insight into how inequality might respond to a step change in productivity, such as the changes in agricultural productivity represented by the Green Revolution. Bourguignon and Morrisson (1998) present empirical evidence that inequality and the extent of dualism are positively correlated in the cross-country data.

The attractiveness of Harris and Todaro (1970) as an organizing framework is limited by the assumption of a fixed urban wage. This becomes an especially important consideration when analysing the general equilibrium consequences of capital accumulation and technical progress. More sophisticated analyses, which relax the fixed-wage assumption in various interesting ways, can be found in papers by Stiglitz (1974, 1976, 1982), Calvo (1978), Moene (1988), Bencivenga and Smith (1997), MacLeod and Malcomson (1998), Brueckner and Zenou (1999) and Agénor (2004) among others. A central challenge is to develop general equilibrium models that not only illuminate the relationships between different types of growth and poverty, inequality and urban underemployment, but also generate testable implications. Given the increasing availability of detailed microeconomic data for developing countries, there is renewed scope for learning about the nature of urban and rural labour markets, and how the workings of these markets are likely to interact with changes in productivity.

Small-scale general equilibrium models are natural candidates for the quantitative investigations, based on structural models calibrated to data, that play a central role in recent work on aggregate development by macroeconomists. There has been some theoretical work on formalizing aggregate effects of various labour market institutions or distortions, such as unionization in Bertocchi (2003). But quantitative investigations of structural models remain rare, especially for developing countries.

11 Conclusions

The central argument of this paper is easily stated: two-sector models deserve a central place in the analysis of growth in developing countries. To support this argument, the paper discusses the deadweight losses associated with factor misallocation; the implications of wage differentials for growth accounting and growth regressions; two-sector models that allow for increasing returns to scale; and the consequences of dual economy ideas for level-accounting decompositions. Some of these ideas could loosely be characterized as putting development economics back into growth economics, an important project begun by Ros (2000) and one that deserves wider research attention.

It is not difficult to point to weaknesses of the dual economy framework, and simple 2×2 models are less attractive than the three-sector dependent economy model in some respects. Moreover, the usual aggregation of industry and services into a single non-agricultural sector begs a number of questions: more than 30 years ago, Dixit (1973) pointed to the neglect of the service sector in much of the literature. Much the same point could be made today, and there is clearly scope for more analysis of service-sector productivity in developing countries, a task for which richer models will again be needed. Eswaran and Kotwal (2002) is a recent example.

Despite the analytical limitations of two-sector models, they can form the basis for interesting analyses of many issues not considered in depth here. These include taxation, and the effects of government policy on peasants and city-dwellers, respectively, as in Sah and Stiglitz (1992). This provides a direct link between dual economy models and the literature on 'urban bias'. Elsewhere, the basic ideas of the Harris–Todaro model continue to have some influence in regional science, as discussed in Allen (2001) and Ingene (2001), and models of imperfect labour markets could be integrated into the literature on the new economic geography (Fujita *et al.*, 1999). The dual economy model can also be used to think about the evolution of population growth, if fertility rates differ between rural and urban areas, as in McIntosh (1975) and Robertson and Wellisz (1979). Cuddington (1993) and Cuddington and Hancock (1995) use dual economy models to examine some of the economic impacts of AIDS in high-prevalence countries.

Perhaps above all, small-scale general equilibrium models can be used to investigate the interactions between growth and labour markets, to shed new light on the origins of pro-poor growth and to explore the role of the informal sector. These models will be essential if growth economists are to engage with the idea of different types of growth, including growth that is pro-poor or growth that is 'labour intensive' in the sense of creating formal sector employment. With fresh interest in these issues, combined with the increased availability of data on developing country labour markets and

distributional outcomes, there are many opportunities for further work in this direction.

Appendix: Equilibrium Wage Differentials

Many applied studies of dual economy models incorporate wage differentials, including Dowrick and Gemmell (1991), Temple (2001, 2004), Temple and Woessmann (2004) and Vollrath (2004). This Appendix briefly sketches ways in which a rural–urban wage differential might arise. The discussion emphasizes models that lead to a fixed differential depending only on structural parameters, and not on endogenous variables such as the level of wages, or the intersectoral allocation of labour. This fixed ratio then corresponds to the differential $d = w_m/w_a$ that is discussed at various points in the main text.

There are many ways in which a wage differential, and especially an urban wage premium, can arise in equilibrium. For some developing countries, trade unions may have some influence in raising the urban wage above the rural wage, as in Calvo (1978). A useful review of economic models of trade unions is provided by Cahuc and Zylberberg (2004). The simplest story is that a single union sets the wage to maximize an objective function, and a firm then chooses the employment level to maximize profits. For example, the union's objective function could take the form

$$(w_m - w_a)^{\phi} L_m \tag{22}$$

where L_m is the number of union members employed by the firm. After the wage has been set, the firm must choose employment to maximize profits:

$$\max_{L_m} R(L_m) - w_m L_m$$

where $R(L_m)$ is the revenue function. Hence the problem for the union is to maximize (22) with respect to w_m, subject to the constraint that the firm operates on its labour demand curve

$$R'(L_m) = w_m$$

If we assume a simple functional form such as $R(L_m) = L_m^{\theta}$ where $\theta < 1$ then it is easy to show that this structure leads to a fixed rural–urban wage differential that is increasing in ϕ and decreasing in θ. Devarajan *et al.* (1997) use a more complicated objective function for the union, generating a wage differential that varies with the size of the urban sector. Note that in the example above, the wage and employment levels are not efficient, since there are alternative combinations of wages and employment that can make at least one party better off and none worse off. For more discussion, see Cahuc and Zylberberg (2004).

A more common approach to modelling an urban wage premium is to use ideas from the efficiency wage literature. One simple example arises if the effort of workers in the urban sector is increasing in the gap between the urban and rural wage, so that production in the urban sector might be given by

$$Y_m = A_m K_m^{\theta} (E L_m)^{1-\theta}$$

$$E = (w_m - w_a)^{\phi}$$

It is easy to show that when urban firms choose their wage and employment level to maximize profits, there will be an equilibrium wage differential which is increasing in ϕ. An implication of this specific model is that, as the economy grows and wages increase, the absolute gap between wages in the two sectors will increase (given their fixed ratio) and hence labour effort increases over time in the urban sector. Ros (2000), Landon-Lane and Robertson (2003) and Agénor (2004) consider alternative dual economy models in which labour effort depends on wages.

Moene (1988) provides another theory. His paper applies the Shapiro–Stiglitz shirking model of efficiency wages to a dual economy (see also Brueckner and Zenou, 1999). The argument uses Bellman equations that must hold in a steady state. The agricultural wage is assumed to be competitively determined and equal to w_{a}. There is full employment in agriculture. The present value of urban employment W is defined by

$$\delta W = w_{\mathrm{m}} - b(W - U) \tag{23}$$

where w_{m} is the urban wage, δ is the discount rate, b is the exogenous hazard rate of a job separation and U is the present value of unemployment. In words, this says that the flow return to urban employment is the urban wage minus the capital loss associated with changing state from employment to unemployment.

We can also write down a migration equilibrium condition. If incomers to the city must experience a spell of unemployment before finding work, a long-run migration equilibrium requires the present value of unemployment to equal that of rural employment:

$$\delta U = w_{\mathrm{a}}$$

Here I will depart slightly from Moene (1988) and assume that urban workers who shirk are moonlighting, receiving income from another job. Workers who shirk produce no output for their formal employer and receive income elsewhere, equal to cw_{m} where $c \le 1$. Moonlighting in this way is detected with a hazard rate q, at which point the worker is fired and returns to unemployment. Hence the flow return to being a shirker is

$$\delta W^{\mathrm{S}} = w_{\mathrm{m}} + cw_{\mathrm{m}} - b(W^{\mathrm{S}} - U) - q(W^{\mathrm{S}} - U) \tag{24}$$

Firms will seek to deter shirking, and for there to be no shirking in equilibrium we require

$$\delta W \ge \delta W^{\mathrm{S}}$$

Assuming this no-shirking constraint binds in equilibrium means, from (23) and (24), that

$$cw_{\mathrm{m}} - q(W^{\mathrm{S}} - U) = 0$$

Hence

$$\delta(W - U) = \delta(W^{\mathrm{S}} - U) = \frac{\delta cw_{\mathrm{m}}}{q}$$

Using this and (23) implies

$$w_{\mathrm{m}}\left(1 - \frac{bc}{q}\right) = \delta U + \frac{\delta cw_{\mathrm{m}}}{q} = w_{\mathrm{a}} + \frac{\delta cw_{\mathrm{m}}}{q}$$

where the last equality follows from the migration equilibrium condition. This implies the following wage differential:

$$d = \frac{w_{\mathrm{m}}}{w_{\mathrm{a}}} = \frac{q}{q-(b+\delta)c}$$

and hence we have an urban wage premium that is a function solely of structural parameters, assuming the detection probability q is sufficiently high for an equilibrium.

Alternative efficiency wage arguments have been applied to rural–urban wage gaps. Bencivenga and Smith (1997) and Eicher (1999) consider two-sector models with adverse selection in the urban labour market: employers are willing to pay high wages in order to influence the pool of applicants. In Bencivenga and Smith (1997), this leads to a wage differential between urban and rural work, for skilled workers, that is a function of structural parameters, including the productivity of labour in the informal sector.

MacLeod and Malcomson (1998) analyse a model in which workers can be motivated by either efficiency wages or bonus schemes (performance pay). They consider a two-sector model where one sector is relatively capital intensive, and can be interpreted as urban non-agriculture. In equilibrium, the two sectors may use different reward schemes, and this generates a wage differential related to the extent of labour turnover in the capital-intensive sector, the disutility of effort and the discount factor. Other interesting approaches to wage differentials can be found in Caselli (1999), Caselli and Coleman (2001) and Lucas (2004). In Caselli (1999) and Caselli and Coleman (2001), an inter-industry wage premium arises when an investment in additional education/training is needed to work in a particular sector. This may be an especially promising approach.

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